

Determination Of Some Heavy Metals in The Effluent of Paint Industry in Wukari, Taraba States-Nigeria and Their Environmental and Human Health Associated Risks.

OKPAEGBE, U.C¹, AZUAGA, T.I², AND ³OGUGUA, S.C³

^{1,3}Department of Chemistry, Federal University Wukari. Taraba State-Nigeria.

²Department of Industrial Chemistry, Federal University Wukari. Taraba State-Nigeria.

Abstract- In this research work, effluent from paint industry found in Wukari, Taraba State, North eastern Nigeria was collected for the determination of some heavy metals such as Cadmium (Cd), Lead (Pb), Manganese (Mn) and Zinc (Zn) using Atomic Absorption Spectrometer (AAS). The samples were digested to yield metal ions (Cd, Mn, Zn, and Pb) with significant homogeneity while removing complex matrix effects using an aqua regia. The heavy metals concentrations before treating the effluent were as follows: Cd 0.039ppm, Zn 0.200ppm, Pb 1.296ppm and Mn 0.260ppm. Comparing these values with the maximum permissible limit (MPL) by WHO of Cd=0.003-0.03mg/L, Zn=0.1-3.0mg/L, Mn=0.4mg/L and Pb=0.01-0.4mg/L, the results obtained shows that Cd and Pb were above MPL, Zn was within MPL and Mn was below MPL by WHO. The results obtained from this study clearly shows that wastewater generated from the paint industry contain residual chemicals that can be toxic to human health and the environment. Therefore, it is essential for routine monitoring of the concentration levels of these heavy metals in the effluent and effective treatment mechanism before releasing them into the environment.

Keywords: Effluent, heavy metals, wastewater, AAS, MPL, WHO.

I. INTRODUCTION

The increased discharge of untreated effluent from paint manufacturing industries, especially in developing nations, has continue to pose associated environmental and health challenges. Statistics has shown that, approximately 70% of the paint industry wastewater is discharged untreated into natural river basins (Nicholas, 2022).

Typical pollutants found in paint industry wastewater include those exerting high values of suspended solids (SS), COD and BOD, heavy metals, and toxic

compounds (Aboulhassan et al.,2006). Organic pollutants have recently attracted public attention, not only as they significantly degrade water quality, but also present major challenges to existing water treatment systems regarding their removal efficiency (Rathi et al., 2021).

Also, about 80% of paint industry effluents come from equipment rinsing (El-shazly et al., 2010; Güven et al., 2017), so after the treatment, effluent, which is now diluted paint, may be used in manufacturing processes as a component of low-cost paints, or as a coolant or dilatant (Vishali et al.,2018). Microbial infection is typical for water-based paints because they contain inorganic and organic materials.

The microbial infection occurs during the manufacturing stages of paint production and storage. The changes in various kinds of physical and chemical properties, such as high temperatures and humidity, increase the possibility of microbial contamination in paint (La Rosa et al.,2008). Therefore, wastewater created during manufacturing can be highly contaminated with microorganisms.

Wastewater generated during the cleaning of paint manufacturing equipment might be highly contaminated with not only organic compounds and pigments but also microorganisms (Dursan and Sengul, 2006).

Paint industry wastewater contains various organic solvents, pigments, surfactants, and other chemicals but also solid particles, heavy metals, oils, etc. Therefore, treatment before discharge into the environment is needed to suit the prescribed standards. It was reported that many paints

manufacturing industries discharge effluents without treatment; even though wastewater treatment plants are inefficient in bringing wastewater conditions to environmentally acceptable safe limits (Nair et al.,2021).

Industrial wastewater treatment techniques may vary depending on their composition, origin, and the specific company. The commonly used methods include coagulation, adsorption (El-Sawy et al., 2013); flocculation, filtration, electrochemical processes (Nair et al., 2021), advanced oxidation processes, and biological processes such as composting. Nowadays, a combination of different effective treatment methods is also used to safely dispose of or, recycle the treated wastewater (Balik and Aydin, 2016; Salihoglu et al., 2018; Gül, 2020; Barbosa et al.,2018).

II. MATERIALS AND METHODS

All the chemicals used were sourced locally, and of analytical grade with high percentage purity.

Sample Collection

The wastewater was directly collected from the raw effluent using 100ml sample bottles. The samples were then packaged and then handled carefully and taken to the Central Laboratory at Federal University Wukari, Taraba state. On arrival the samples were collected and kept in a cool and dry place under room temperature for about three days, before proceeding with analysis at the central laboratory.

Procedure of Sample Digestion

An aqua-regia was prepared by mixing 25 mL concentrated nitric (V) acid and 75 mL concentrated hydrochloric acid at ratio 1:3. The acids were used to break down the bonds between the metal ions and the matrices in the effluents. This was carried out by measuring 20 mL of the effluent sample using a clean 100 mL measuring cylinder and transferred into a clean 250 mL beaker.

The 100 mL of the aqua-regia solution was added, and the resulting mixture was thoroughly mixed to

ensure homogeneity of the sample. The resulting mixture was subsequently heated for 30 minutes on a hot plate placed in a fume cupboard, until the volume was reduced to 100 mL. Distilled water was added, and heating continued for about 15 minutes. The solution was allowed to cool and then filtered using a filter paper to remove suspended solids.

The solution was afterward diluted with distilled water to the 50 mL mark. Without the sample solution, a blank solution was made using de-ionized and distilled water. The digested samples were kept in sample containers pre-treated with concentrated nitric (V) acid and rinsed with distilled water. The samples were then analysed using the Atomic Absorption Spectrometer (AAS).

Preparation of Standard Solutions

The standard solutions for each metal (Pb, Cd, Zn and Mn) were prepared by taking 1 g of each distinct metal salt into distilled-deionized water and making up to one litre in a volumetric flask. The standard solutions were prepared from 100 ppm by pipetting 10 mL of the solution into calibrated 100 mL volumetric flasks and topped to the mark using distilled water to obtain 10 ppm. The AAS equipment was calibrated using five standard solutions.

The AAS equipment and appropriate hollow cathode lamp and wavelength were selected for each metal, as shown in Table 1. The digested samples and blank solutions then were aspirated into the optimized AAS equipment, and their absorbance was determined differently. The concentration of Pb, Mn, Zn and Cd in the effluent samples was then obtained.

III. RESULTS AND DISCUSSION

AAS Optimized Parameters

The AAS equipment and appropriate hollow cathode lamp and wavelength were selected for each metal, as shown in Table 1.

Table 1 AAS Optimized Parameters

Metal	Flame	Wavelength (nm)	Detection Limit (mg -1)	Lamp Current (mA)
Lead (Pb)	Air AcetyleneFlame	217.00	0.01	15.00
Manganese (Mn)	Air AcetyleneFlame	279.50	0.10	20.00
Cadmium (Cd)	Air AcetyleneFlame	228.80	0.02	10.00
Zinc (Zn)	Air AcetyleneFlame	213.9	5.00	15.00

Heavy Metals Analysis

The results of heavy metal, and efficiency determinations of the effluents from the sampled point from the paint Industry located in Wukari, Taraba State, North Eastern Nigeria are summarized in Tables 2. The concentration of the analyzed heavy metals (Pb, Cd, Zn and Mn) was compared to the Maximum Permissible Limits (MPL) of WHO's regulations.

Table 2: Concentration of heavy metals in the sample against MPL of WHO

Heavy metals analyzed	Concentration of heavy metals in effluent (BTE)	MPL (WHO)
Cadmium (Cd) levels (ppm)	0.039	0.003-0.03
Lead (Pb) levels (ppm)	1.296	0.01-0.4
Manganese (Mn) levels (ppm)	0.260	0.4
Zinc (Zn) levels (ppm)	0.200	0.1-3.0

The concentration of Lead (Pb) metal analysis was 1.296 in the sample obtained from the wastewater collected. This value is above the range of MPL for WHO's regulations. Hence the discharge of water into the municipal sewer is unacceptable but acceptable only after treatment. The high concentration of the Lead element may be attributed

to the Lead pipes used to channel the industrial effluent to the wastewater collection point, Lead component in the raw materials and other chemicals used during the process of production e.g. pigments, binders, solvents etc.

High levels of Lead accumulation in the environment have a negative impact on both the biota and human health at large. Some of the health effects of Lead on human beings are alteration of haemoglobin biogenesis and anaemia, increase in blood pressure, brain damage, miscarriages, and subtle abortions, a decline in fertility of men by damage of sperm and childhood behaviour disorders such as hostility, impulsivity, and restlessness.

Manganese (Mn) metal analysis was 0.260 in the sample obtained from the wastewater collected. The value obtained is below the range of MPL for WHO's regulations. Although manganese is needed in the body to strengthen bones and growth of tissues which is good that its concentration is low and acceptable by WHO's MPL. The presence of Manganese may be attributed to the inorganic compounds that are used in the manufacture of Manganese phosphate.

Phosphates are used as surface coatings to enhance corrosion resistance. Release of high concentration of Manganese into the environment may result in various side effects such as impotence in men due to prolonged exposure, Parkinson in men, Lung embolism, bronchitis, and hallucinations. These side effects are possessed by persons who have consumed food products contaminated with Manganese.

Cadmium (Cd) metal analysis was 0.039 in the sample under consideration. The value is above the range of MPL for WHO's regulations. The presence of Cadmium in the samples is attributed to it being a component in the raw materials and other chemicals used during the process of production e.g. pigments, binders, solvents and driers.

Although recent technology has developed cadmium-free raw materials for cadmium-free based paints, but some of the paint manufacturing industries have not fully complied to using Cadmium-free based paints in Nigeria. Cadmium exposure can lead to bone demineralization which can occur directly from bone destruction or indirectly as a result of renal dysfunction. Excessive industrial exposure to airborne Cadmium may impair lung functionality thus increasing the risk of cancer of the Lung contraction.

The concentration of Zinc (Zn) metal analysis was 0.200 in the sample obtained from the waste water collected. The value was within the range of MPL for WHO's regulations. Although humans can handle proportionally large concentration of Zinc, too much Zinc can still cause eminent health problems, such as stomach cramps, skin irritations, vomiting, nausea and anaemia. Very high level of Zinc can damage the pancreas and disturb the protein metabolism, and cause arteriosclerosis. Extensive exposure to zinc chloride can cause respiratory disorders. In work place environment zinc contagion can lead to a flu-like condition known as metal fever.

Health and environmental risks

An elevated concentration of heavy metals increases the potential of adverse health effects to inhabitants in each environment (WHO & UNICEF, 2017). Some common health effects associated with heavy metal poisoning include blindness, organ damage and breathing related problems (Kauret al.,2010).

The toxicity of heavy metals depends on their chemical form and the species of the elements. For some metals, the most toxic form is that having alkyl groups attached to the metal since most of such compounds are soluble in animal tissues and can pass through biological membranes. Cadmium (Cd) has high soil mobility than any other metal to plant

system. In human, only about 5% - 50% of the inhaled element ever enters the lungs.

Also, only 1% - 10% Cd gets into the digestive system via ingestion of food and water intake. Chronic exposures to Cd result in renal tubular damage, bone deformities, and heart related diseases (Ohioma et al.,2009). Zinc plays a very important role in plant nutrition; it has been a component of a number of metallo-enzymes. Zinc is an essential beneficial element of human beings, but their element salts produce undesirable taste to water.

It is discharged into sewage and soils from pharmaceutical paints, pigment, several insecticides and cosmetic industry. Although Zn has been found to have low toxicity to man, prolonged consumption of large doses can result in some health complications such as fatigue, dizziness, and neutropenia (Zak et al., 2014).

Excessive and prolonged inhalation of Mn particulate in mining, welding and industries results in its accumulation in selected brain regions that causes central nervous system (CNS) dysfunctions and an extrapyramidal motor disorder, a recent report suggested that, some aspects of disease may also occur in individual, because of exposure from environmental source (Chidozie and Nwakanma, 2017).

CONCLUSION

Heavy metals such as lead, mercury, cadmium, etc., are usually part of the manufacturing processes in paint and coating industry, and the wastewater generated from these industries usually contain residual chemicals (heavy metals inclusive), that possess' great danger to humans and the environment.

This study clearly shows that wastewater generated from the paint industry under consideration, contain the aforementioned chemicals that can be toxic to human health and the environment. Therefore, it is essential for routine monitoring of the concentration levels of these heavy metals in the effluent and effective treatment mechanism before releasing them into the environment, so as to safeguard both humans and the environment.

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